Ocean Acoustic Observatory Federation

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LONG-TERM GOALS

To establish and maintain a sparse network of acoustic receivers and sources and to make the data collected available for research. The observatories serve a dual purpose: capitalize on the proven potential for acoustics and observatories as oceanographic tools and maintain the momentum towards unveiling the ultimate limits to underwater surveillance.

OBJECTIVES

There are several objectives in our research:

- Instrument and operate several retired SOSUS stations in the Pacific with the goal of archiving a large, continuous collection of data which can be used to study oceanographic phenomena including acoustics, climate, seismology, and biology.,
- Monitor the acoustic environment near the Acoustic Thermometry of Ocean Climate (ATOC) source in Kauai,
- Operate and maintain the Naval Postgraduate School (NPS) ocean acoustic observatory,
- Conduct ocean acoustic tomography experiments in the vicinity of coastal North America,
- Monitor, in real time, marine mammals, earthquakes and volcanoes in the NE Pacific,
- Use portable acoustic stations for monitoring marine mammal migration and behavior in the NE Pacific, and
- Conduct research on the data collected to integrate acoustic and satellite data, understand the coupling of elastic energy to acoustic signals capable of propagating large distances, coastal tomography and thermometry, and earthquakes and volcanoes in the northern Pacific.

APPROACH

The members of the Ocean Acoustic Observatory Federation are:

Scripps Institution of Oceanography
    John Orcutt, Bill Kuperman, Walter Munk, Peter Worcester, Bill Hodgkiss, and Frank Vernon

Naval Postgraduate School
Curt Collins and Ching-Sang Chiu

University of Washington/Applied Physics Laboratory
Bob Spindel, Bob Odom, and Jim Mercer

NOAA/Pacific Marine Environmental Laboratory
Chris Fox, Eddie Bernard, and Bob Dziak

The roles of the members of the consortium are:

Scripps Institution of Oceanography
Coordinate the activities of the Federation, outfit additional retired SOSUS stations in the Pacific, conduct research in the Pacific basin earthquake and volcano seismicity, monitor whalte activity near the Kauai source with portable stations, cunduct coastal tomographic studies, archive Pacific SOSUS data and integrate SOSUS and satellite data.

Naval Postgraduate School
Operate the NPS ocean acoustic observatory and conduct ocean margin tomography.

University of Washington/Applied Physics Laboratory
Outfit retired SOSUS stations, conduct research in Pacific ocean basin phenomenology using SOSUS, and integrate SOSUS and satellite data.

NOAA/Pacific Marine Environmental Laboratory
Monitor in real time NE Pacific marine mammals, earthquakes and volcanoes, integrate SOSUS and satellite data and use portable stations in monitoring.

WORK COMPLETED

The mechanism for generating T-waves at the seafloor has not been thoroughly understood. Ray theory indicates that crustal seismic energy crossing the seafloor interface into the overlying water column experiences severe refraction toward vertical due to the large velocity contrasts between water and rock with the consequence that the acoustic energy should not travel far in the water column.

That oceanic T-waves arise from the seismic waves scattered by a rough sea bottom was given support recently by de Groot-Hedlin and Orcutt (1999), who were able to reproduce realistic T-wave coda from several low-order acoustic modes excited by point sources distributed over the sea floor. Assuming the excitation to be proportional to the acoustic modal amplitude at the point where the exponential tail contacted the bottom, they synthesized T-wave signal envelopes, which showed good agreement with the measured envelopes. They suggest that the remaining discrepancies between the modeled and measured energy envelopes arise from coarse bathymetry, mode coupling and radiation pattern effects.

In the past year the UW/APL team addressed the excitation of these modes, and emphasized that the most important feature of the modal representation is the mutual orthogonality of the modes, making it impossible to transfer energy from one mode to another if the earth were truly a layered semi-infinite half-space or a radially symmetric sphere. The physical mechanism for T-wave generation requires something that breaks the strict modal orthogonality.

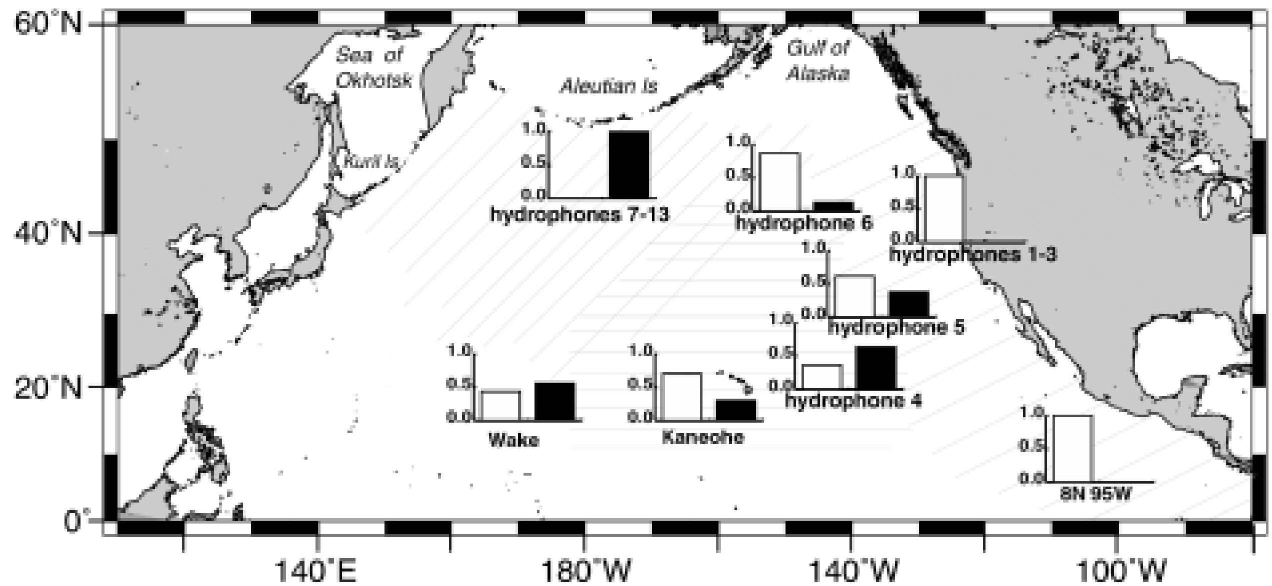
Odom’s group applied a coupled-mode based scattering theory (Park and Odom, 1999) to the excitation of the T-waves within the earthquake epicentral region. The medium is characterized by some deterministic range-dependent layered structure superposed with a small random boundary fluctuation. The model used corresponded to a T-wave producing earthquake that occurred near the near the western tip of the Blanco Transform Fault Zone in the North Pacific (Lat 44.710, Lon -130.310, mb=3.9, depth=9km).

Because the earthquake hypocenter is far below the ray equivalent turning points of the low order acoustic modes in the SOFAR channel, it is not possible to directly excite the T-waves. Sea bottom roughness, upper crustal hereogeneity, or non-planar bathymetry breaks the strict mode orthogonality and permits energy to be transferred among the modes. Energy has been scattered into the lowest order acoustic modes comprising the T-waves. This work is the subject of a recent publication produced under this grant (Park et al. 2001).

Only the discrete modes have been included. However, we know that for deeper earthquakes, the contribution from the continuum spectrum becomes important. Source mechanism effects including radiation pattern effects, bottom properties including sediment thickness and type, and continuum contributions are currently being investigated. Preliminary additional results indicate that effects of source characteristics appear to be reflected in the T-wave excitation. Dziak (2001) has observed such effects in the data. Surprisingly, T-waves may be useful for source type discrimination.

RESULTS

With the final funding provided by NOPP for the OAOF, the NOAA/PMEL and Oregon State University group at Newport, Oregon completed and published several studies on a variety of topics (see below). In addition, NOPP funds were used to support the final year of study of Kathleen Stafford, who completed her Ph.D. degree in June 2001 at Oregon State University's College of Oceanic and Atmospheric Sciences. Kate has been selected for a National Research Council fellowship at NOAA/NMFS National Marine Mammal Laboratory in Seattle, where she will continue to collaborate with Federation scientists. Support included her salary plus the costs of deploying and maintaining an array of hydrophones in the Gulf of Alaska as part of her dissertation research. An additional array of hydrophones deployed in the eastern equatorial Pacific was maintained under NOPP funding, and the data from these two arrays contributed directly to several other studies undertaken by the project. The figure below shows the reception of whale vocalizations from the northeastern and northwestern Pacific.



Proportion of the northeastern (white bars) and northwestern (black bars) vocalizations at each hydrophone (SOSUS and TAO Array). Hydrophones 7-13 had identical proportions as did hydrophones 1-3 so only one graph is shown for each of these two groups. Proportions were determined by number of hours of one kind of vocalization over the total number of hours of either vocalization. i.e. the proportion of NWP calls would be = NWP calls/(NWP calls + NEP calls

In January 2001, the array cable at the NAVFAC PTSUR SOSUS was severed and all data channels were lost. For one week in July, a dive survey was conducted along the cable route to verify the location of the break. The USS Navajo, a fleet tug, was damaged in a mooring effort on 2-21 Aug 2001 and was unable to affect the repair. The M/V Independence came on station on 11 August and recovered approximately 0.6 nmi of cable and the severed end was brought aboard. The ocean side of the cable was also brought aboard, but another break was detected another 0.5 nmi to sea. Unfortunately, available funding ran out before the cable could be repaired. Unfortuntely, the goals of the repair effort were not met, and the condition of the array cable is uncertain. OAOF plans no further efforts in repairing the cable.

PUBLICATIONS

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